

Solar mass:  
 $1.98 \times 10^{33} \text{ gm}$

Solar radius:  
 $6.96 \times 10^{10} \text{ cm}$

Mean Solar density:  
 $1.410 \text{ gm cm}^{-3}$

Visual magnitude  
of the Sun: -26.73

Absolute visual  
magnitude of the  
Sun: +4.84

Quiescent Solar  
surface  
temperature:  
5800 K

Solar polar rotation  
period: 31.52 days  
(sunspot method)

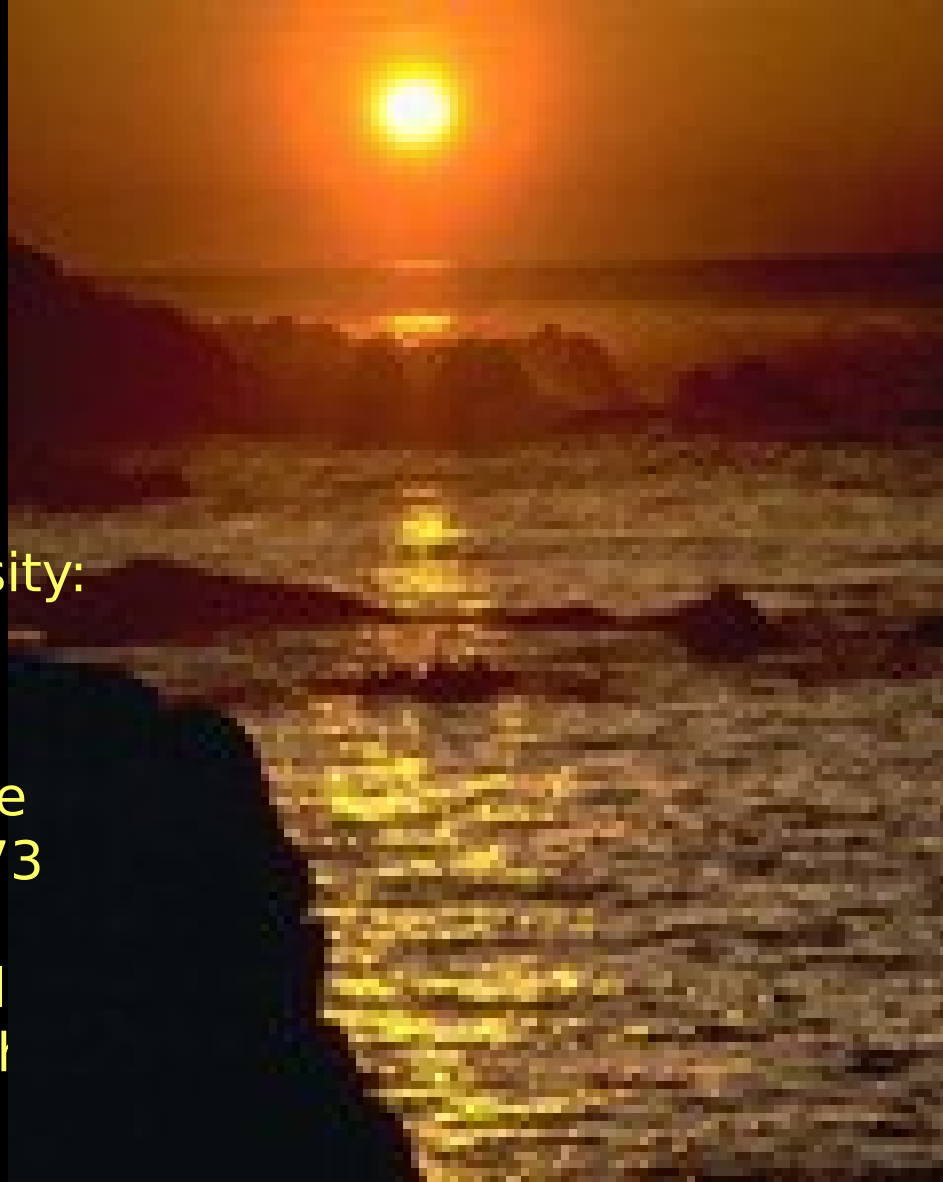
Solar equatorial rotation  
period: 25.0 days (using  
sunspots)

# SUN

Quiescent Solar  
luminosity:  
 $3.83 \times 10^{33} \text{ ergs/s}$

Earth-Sun  
distance:  
(1 AU):  $1.5 \times 10^{13} \text{ cm}$   
Solar constant:  
 $0.1353 \text{ Watts cm}^{-2}$

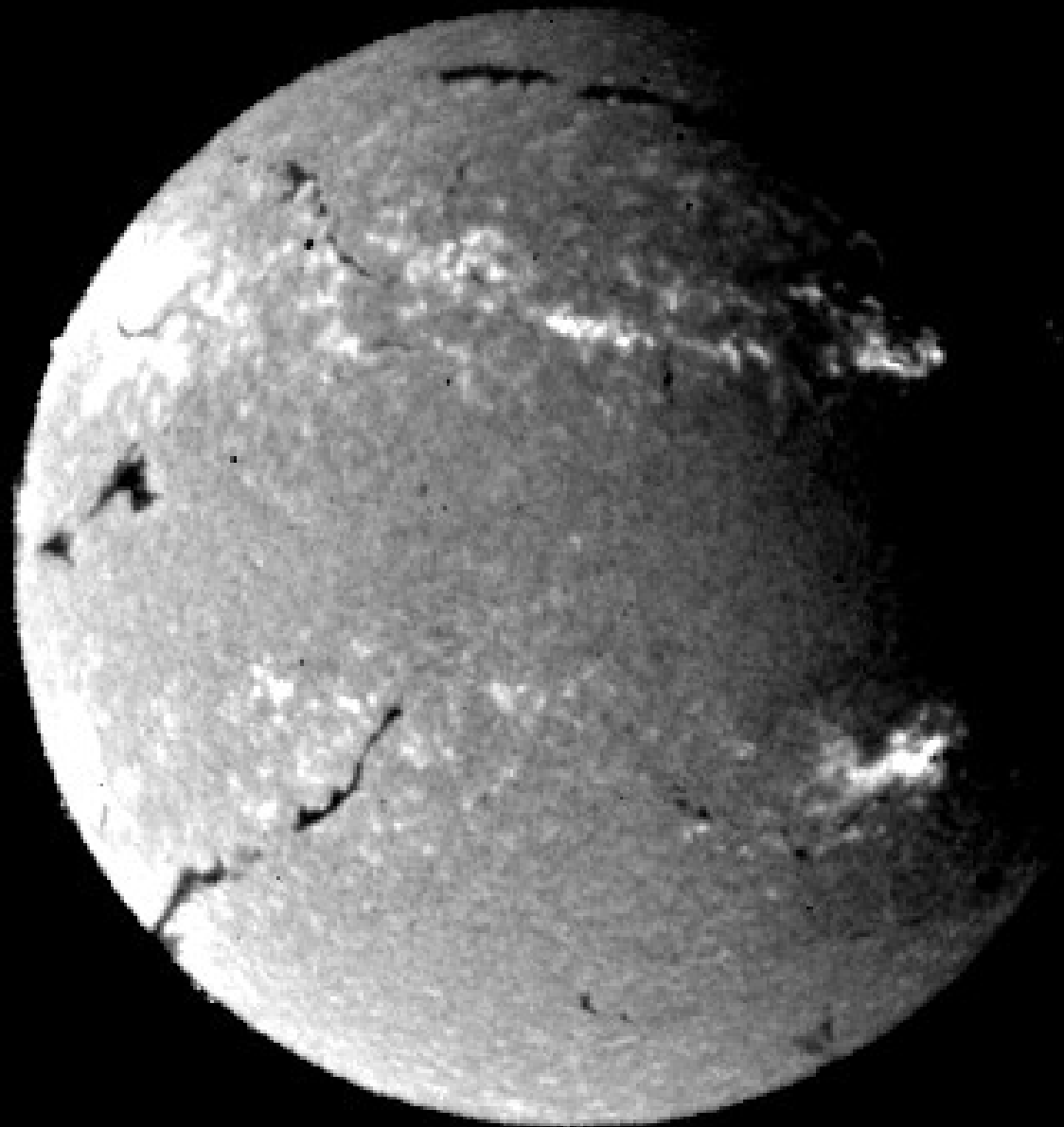
Solar surface gravity:  
 $2.74 \times 10^4 \text{ cm/sec}^2$



# Sun, MLSO, $H\alpha$

$H\alpha$  (6562.8 nm)  
images from  
the High  
Altitude  
Mauna Loa Sol  
ar Observator  
y  
(012199)

$H\alpha$  emission is recombination radiation from hot gas in the photosphere. In the chromosphere, H atoms are heated by thermal conduction and excited by collision. During Solar flares, H is



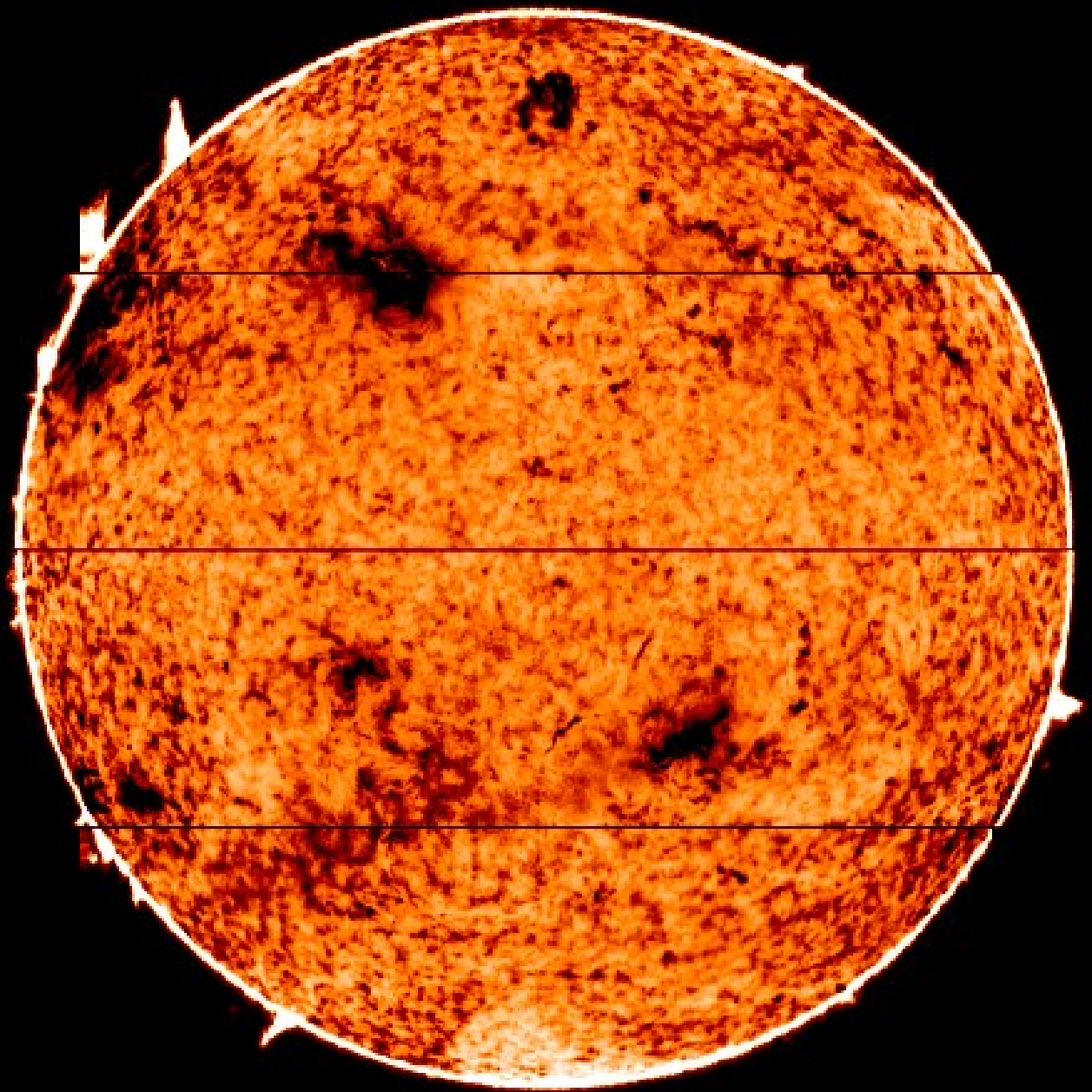
Sun,  
KPNO, He I

He I 10830

□

spectroheli  
ograms  
from the  
U.S.  
National  
Solar  
Observator

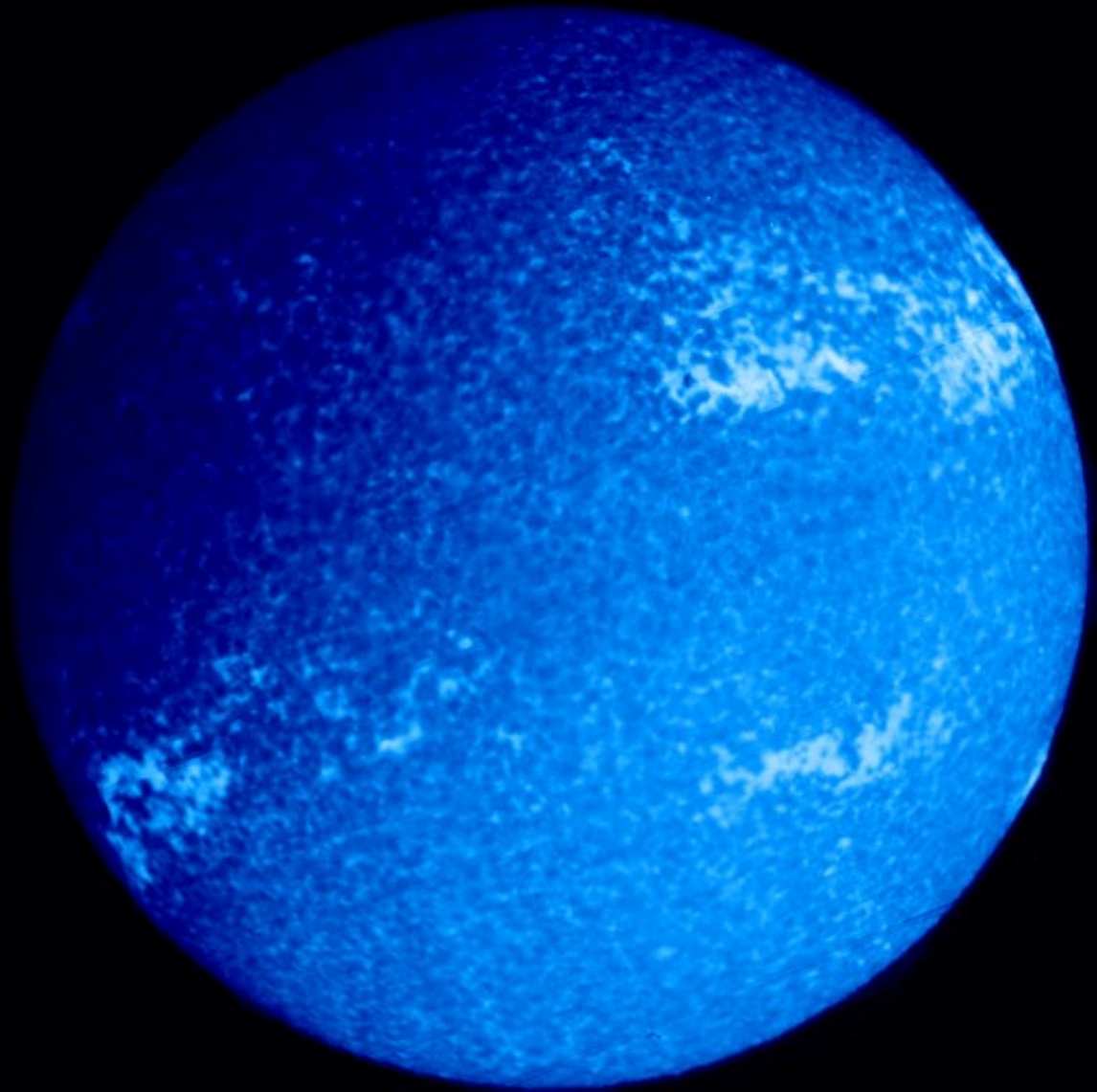
Early observations of  
He I emission,  
coupled with its high  
ionization energy ( $\sim 20$   
eV), revealed  
temperatures at the  
chromosphere and  
corona much hotter  
than at the  
photosphere. The He  
lines are much weaker  
in coronal holes and  
are enhanced in



# Sun, USNSO

**Ca II K 8542  $\lambda$   
spectro-  
heliograms  
from the  
U.S. National  
Solar Observ-  
atory at Sacra-  
mento Peak N  
M (060199)**

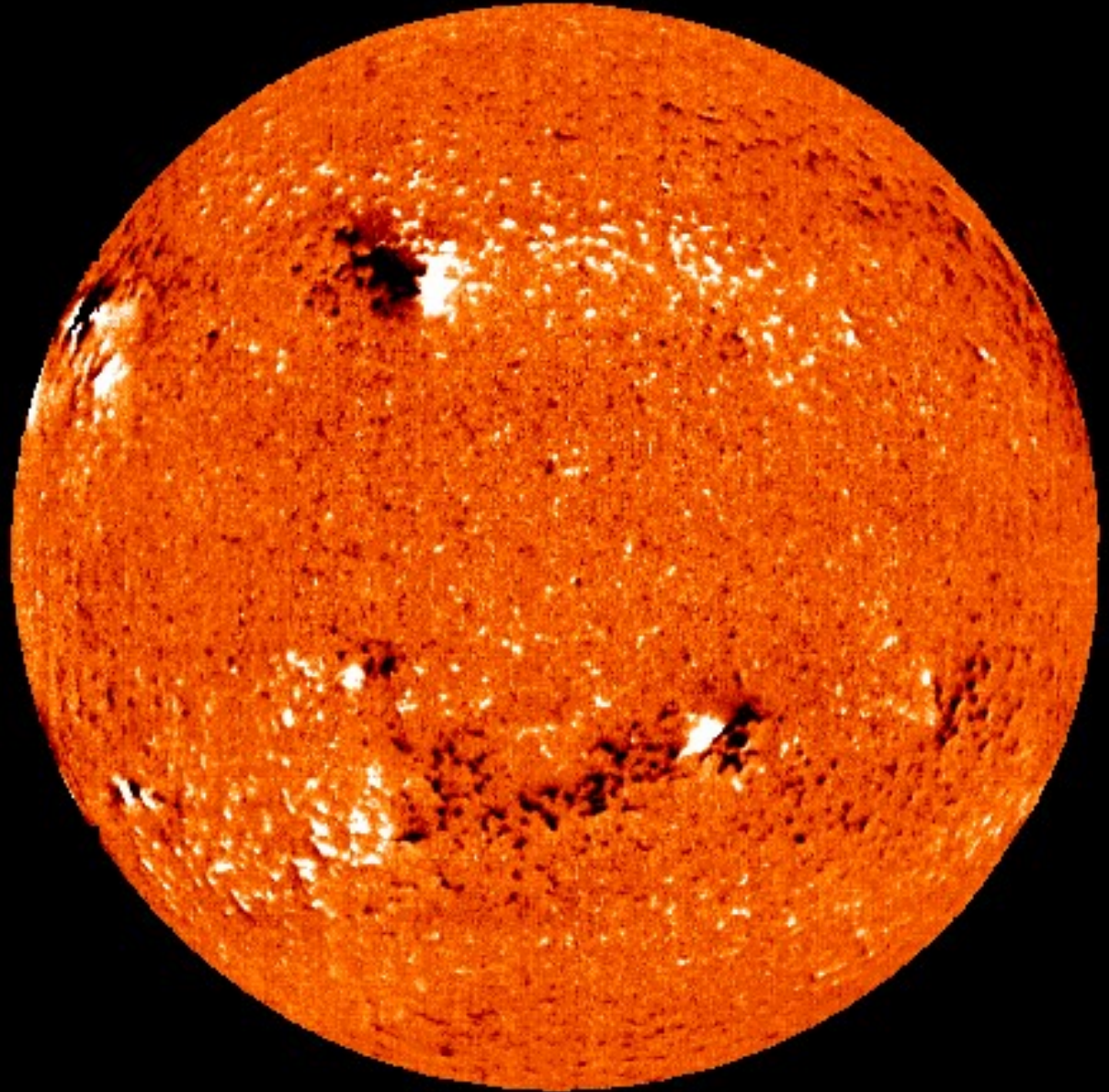
The Ca II  
resonance spectral  
line serves as a  
diagnostic for  
plasma properties,  
activity levels and  
magnetic influence  
of the Solar  
chromosphere. The  
differential  
emissivity provides a



Sun,  
KPNO, Ca II

Ca II 8542  $\lambda$   
magnetogram  
s  
from the  
U.S. National  
Solar Observ  
atory  
at Kitt  
Peak, AZ  
(070299)

Ca II  
magnetograms  
reveal clumps of  
magnetic structure  
that diagnose  
convective motions  
which transport  
energy from the  
Solar interior.



# Sun, KPNO, magnetogram

**Photospheric  
magnetograms  
from the  
U.S. National Sol  
ar Observatory  
at Kitt Peak AZ  
(070299)**

Standard  
photospheric  
magnetograms at  
6303 Å trace the  
magnetic field  
orientation at the  
surface of the Sun.  
Together with  
observations of bright  
points, plumes, and  
active regions, one  
obtains a picture of the  
turbulent mhd activity  
occurring at the Solar



# Sun, MLSO, Coronameter

MLSO-MK3 Coronameter

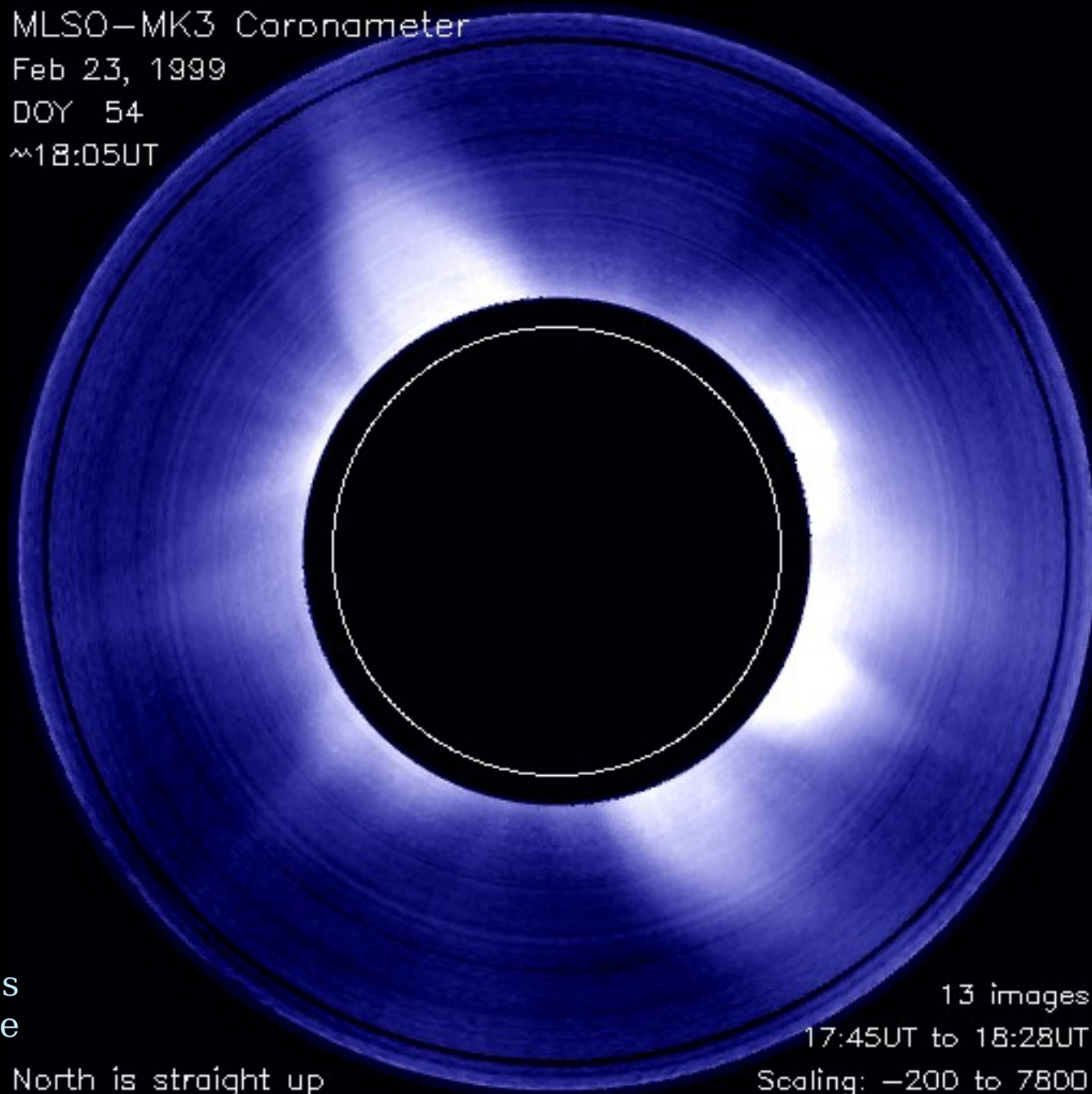
Feb 23, 1999

DOY 54

~18:05UT

**White-light  
coronameter  
images from  
the  
High Altitud  
e Observator  
y Mauna Loa  
Solar Observ  
atory  
(022399)**

**White light**  
(integrated Solar  
emission between  
4000 and 7000 Å)  
coronameter images  
reveal activity of the  
corona



North is straight up

13 images  
17:45UT to 18:28UT  
Scaling: -200 to 7800

Sun,  
LASCO SUMER,  
He I

**He I 584.3  $\text{\AA}$   
emission  
line  
observed  
with  
SUMER on  
2-4 March  
1996**

Sun observed in  
He I, formed in the  
upper **chromosphere** at  
about 20,000 K. The  
picture was put together  
from eight horizontal  
raster scans in alternating  
directions, starting in the  
solar NE. Each raster  
scan includes 1600  
exposures, lasting 7  
seconds each. The picture  
is shown in bins of 4x4



Sun,  
SOHO EIT  
, He II

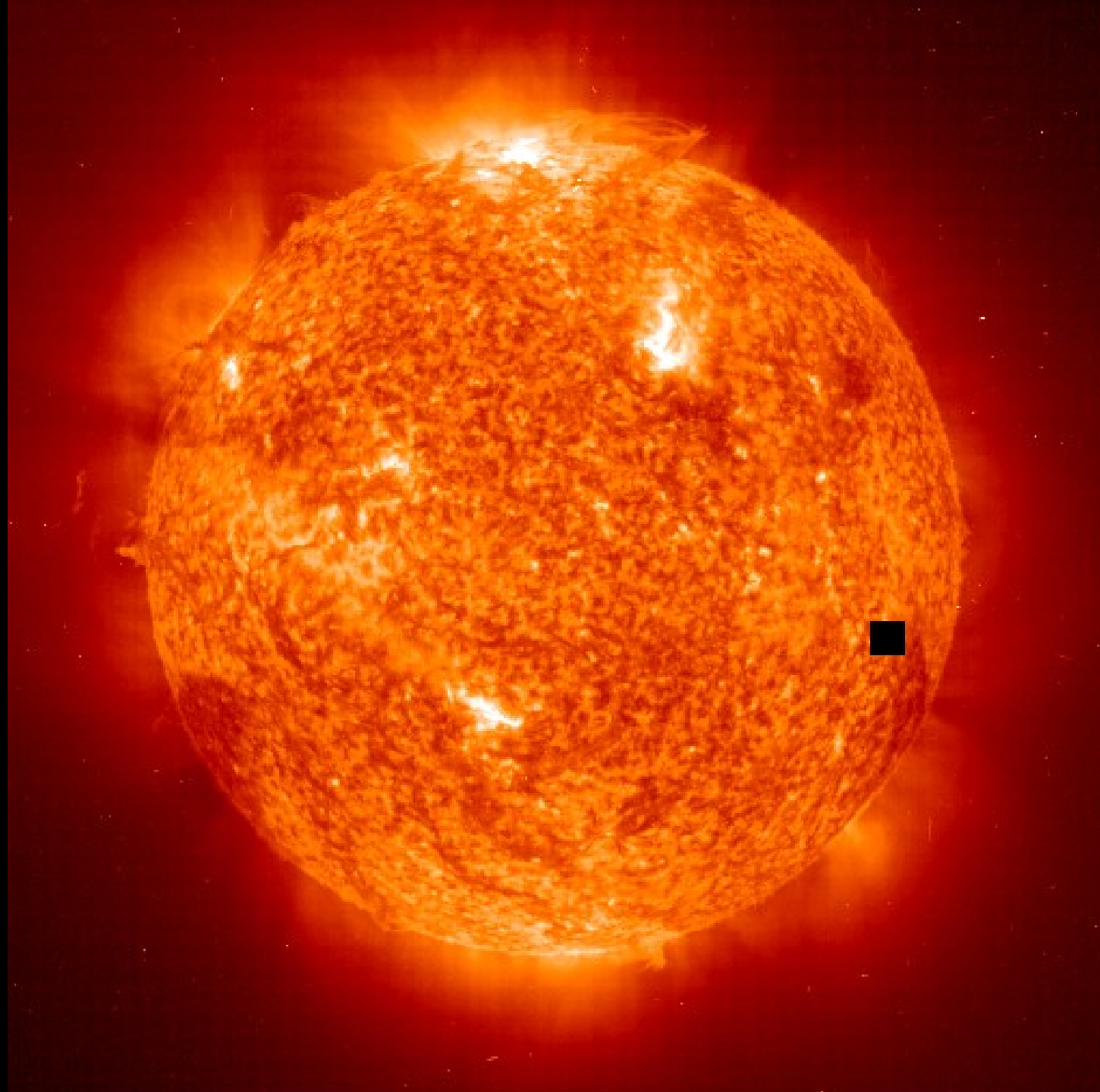
Full-field  
HeII

304 Å

image

(070299)

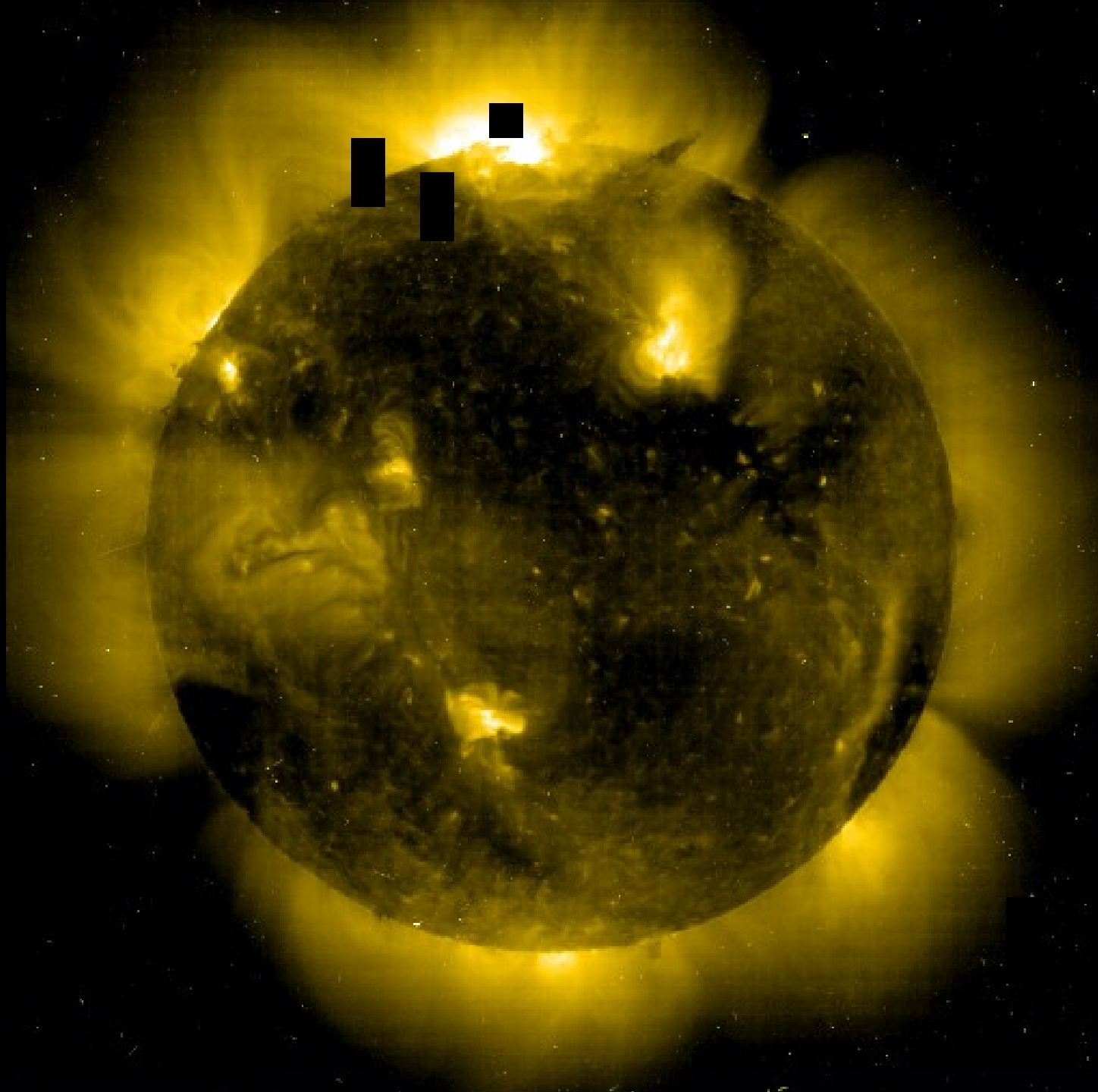
He II emission in the extreme UV is formed by excitation and ionization of He by energetic beamed electrons produced in the low chromosphere. The formation of electron beams may be due to magnetic reconnection in flare loops



Sun,  
SOHO EIT ,  
Fe XV

**Full-field  
Fe XV  
284 Å  
image  
(070299)**

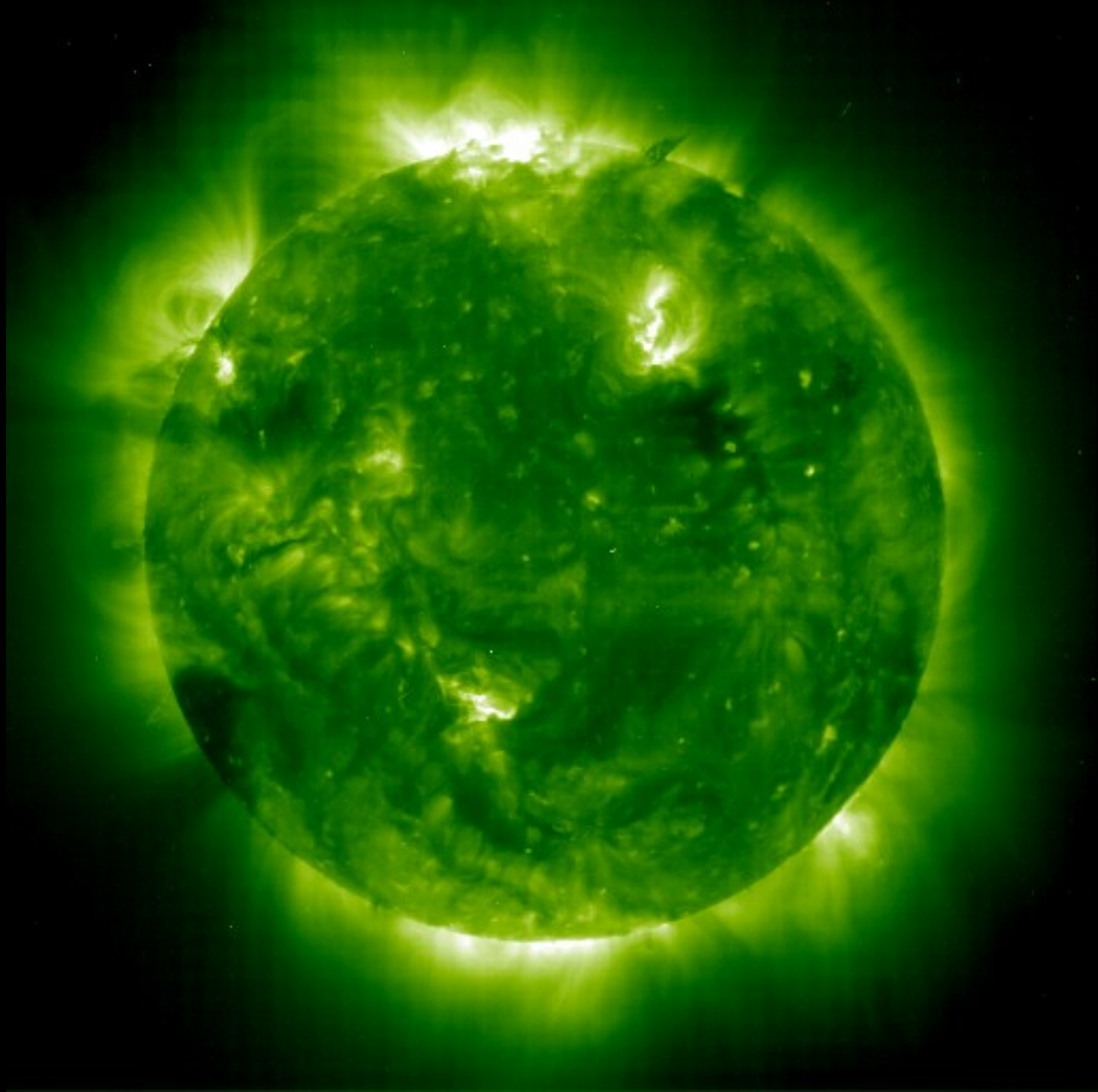
Fe XII-XVIII  
Full- disk images  
in FeXII 195 Å and  
FeXV 284 Å allow  
study of the  
properties of the  
quiet corona  
outside and inside  
coronal holes.



Sun,  
Soho EIT  
, Fe XII

**Full-field  
Fe XII  
195 Å  
images  
(070299)**

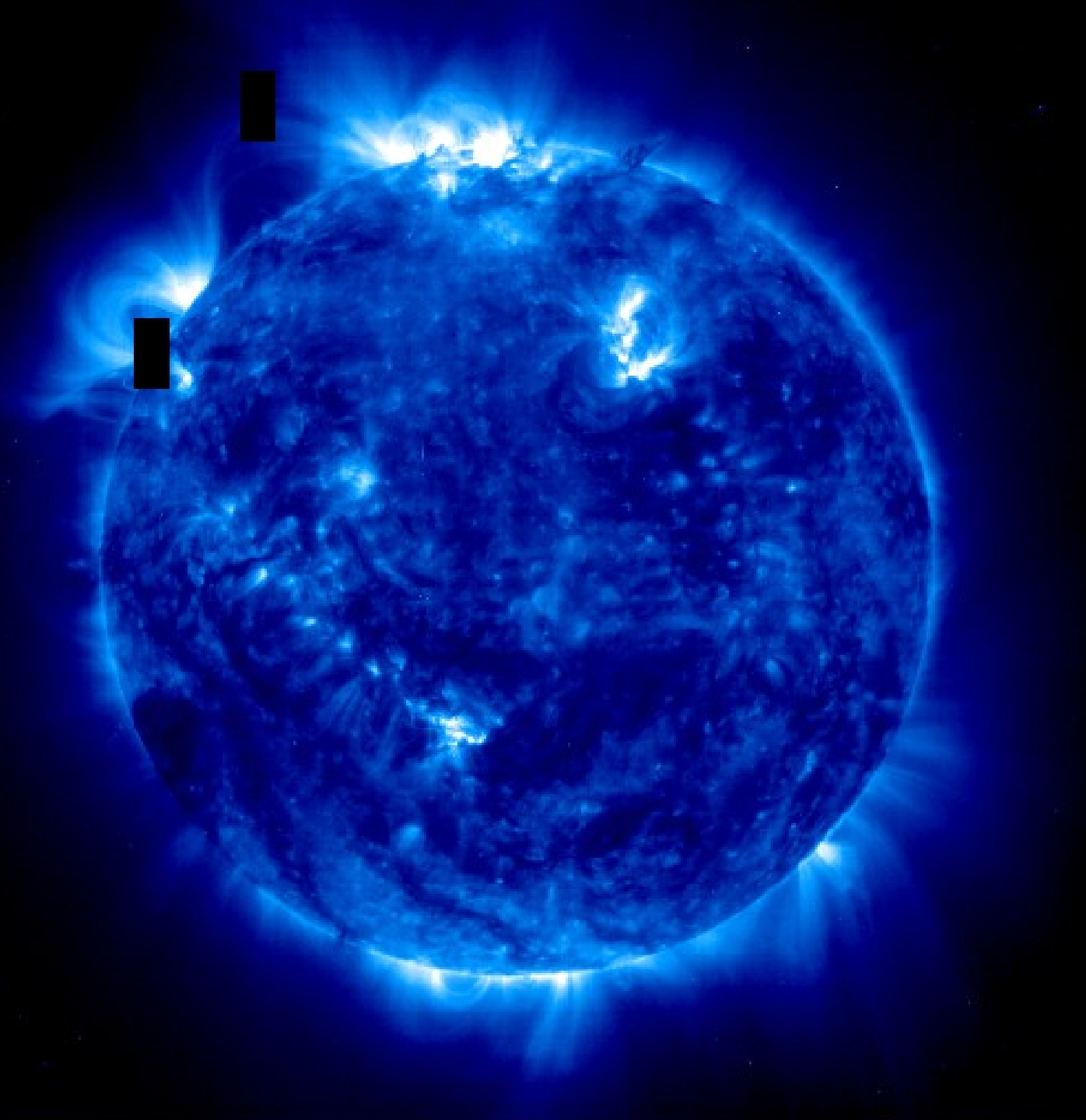
Fe XII-XVIII  
emission is  
formed in the low  
corona ( $2 \times 10^6$  K)  
of the Sun and is  
due to  
recombination of  
electrons with  
ionized Fe.



Sun,  
SOHO EIT  
, Fe IX

Full-field  
Fe IX, X  
171 Å  
images  
(070299)

Full Sun EUV  
images in FeIX-X  
171 Å show the  
latitude-time  
distribution of the  
X-ray bright points  
and their relation  
to the structures  
inside  
coronal holes.



# Sun, Yohkoh

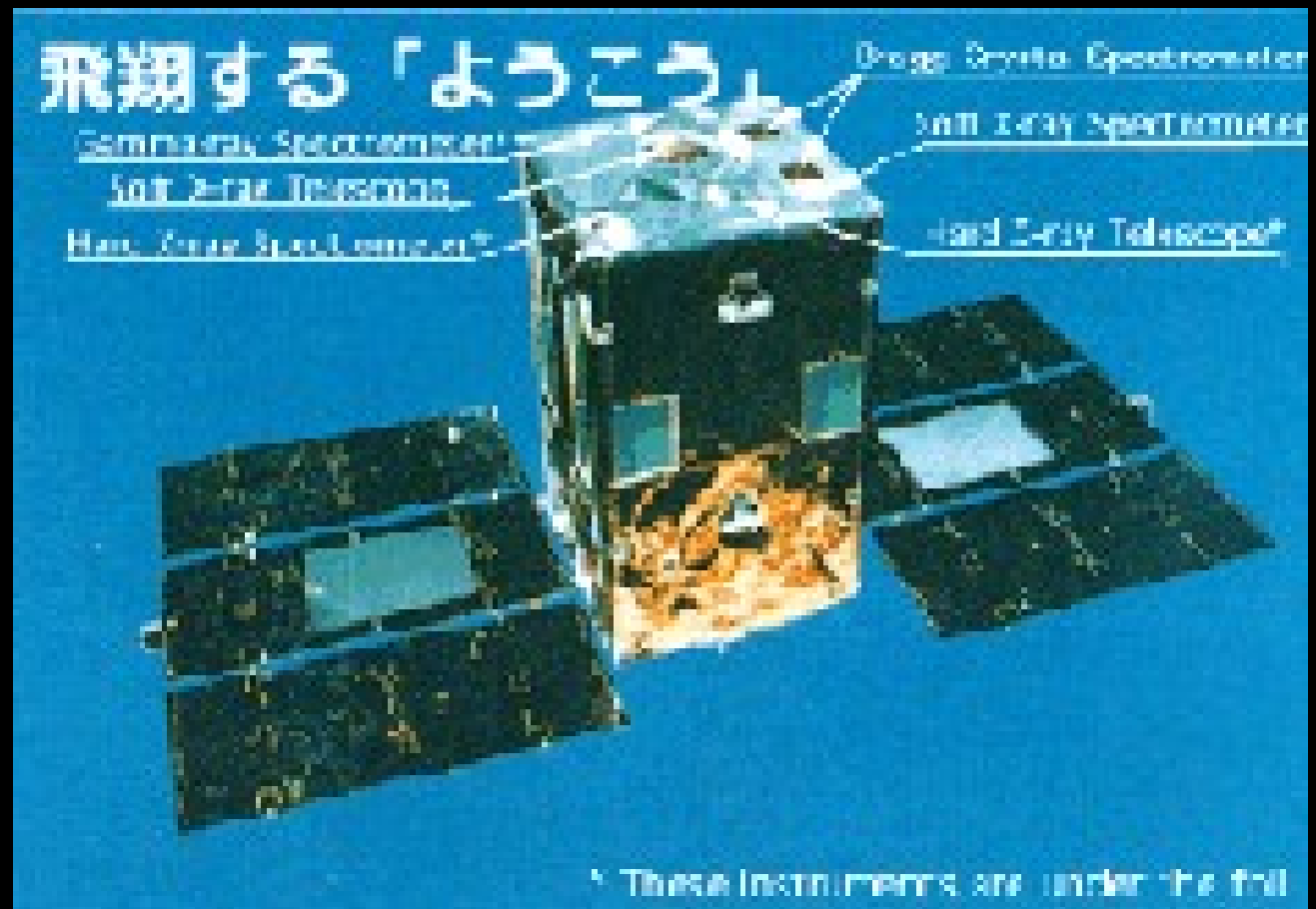
**Yohkoh  
soft X-ray  
telescope  
(SXT) full-  
field  
images  
from the  
Hiraiso  
Solar  
Terrestrial**

**Research X-  
ray  
Center  
(040299)**

rays come  
primarily from  
thermal and  
nonthermal  
continuum electron  
bremsstrahlung and  
X-ray lines due to  
the excitation of  
inner shells of ions



# Yohkoh Satellite



*Yohkoh* ("Sunbeam" in Japanese) is a satellite dedicated to high-energy observations of the Sun, specifically of flares and other coronal disturbances. The *Yohkoh* mission was launched on August 30, 1991, from the Kagoshima Space Centre in southern Japan. The spacecraft carries a payload of four scientific instruments: the Soft X-ray Telescope (SXT), the Hard X-ray Telescope (HXT), the Bragg Crystal Spectrometer (BCS) and the Wide Band Spectrometer (WBS). The SXT (which is sensitive in the range 1-2 KeV) takes images in various wavebands (selected by filters) using a CCD - either the full CCD frame, or a selected part of the CCD frame is returned in telemetry - these are known as full frame, and partial frame images (FFI and PFI); the HXT (which is sensitive in the range 10-100 KeV) measures Fourier components in 4 channels through a set of 64 pairs of grids - the images are reconstructed on the ground; the BCS observes the line emission of Fe XXVII, Fe XXVI, Fe XXV and Fe XXIV.

# SOHO Satellite

- The solar interior

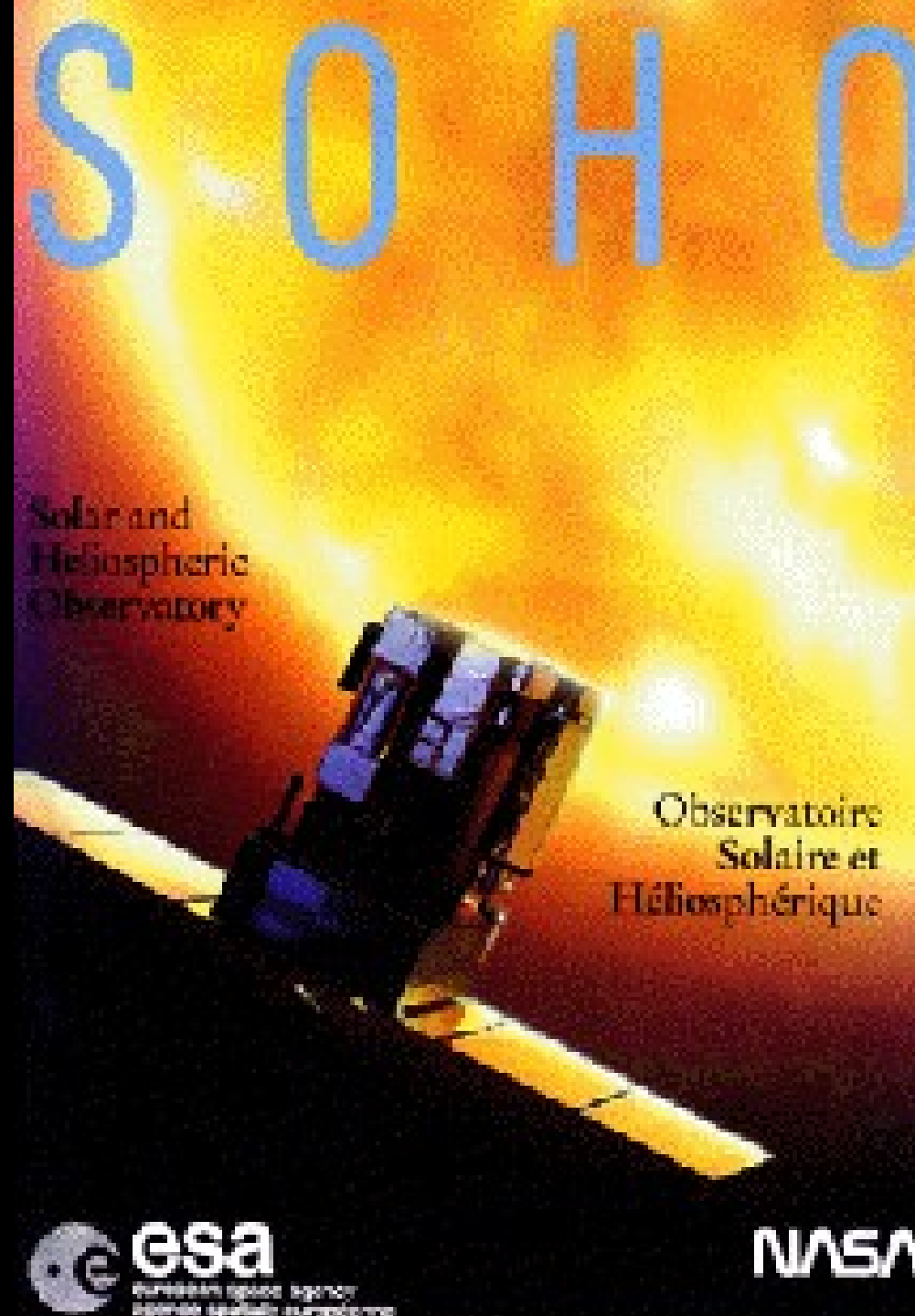
**GOLF** and **VIRGO** will perform long and uninterrupted series of oscillations measurements of the full solar disk, respectively in velocity and in the irradiance domain. In this way, information will be obtained about the solar nucleus. **SOI/MDI** will measure oscillations on the surface of the Sun with high angular resolution. This will permit to obtain precise information about the Sun's convection zone - the outer layer of the solar interior.

- The solar atmosphere

**SUMER, CDS, EIT, UVCS, and LASCO** constitute a combination of telescopes, spectrometers and coronagraphs that will observe the hot atmosphere of the Sun, the corona, extending far above the visible surface. **SUMER, CDS** and **EIT** will observe the inner corona. **UVCS** and **LASCO** will observe both inner and outer corona. They will obtain measurements of the temperature, density, composition and velocity in the corona, and will follow the evolution of the structures with high resolution.

- The solar wind

**CELIAS, COSTEP** and **ERNE** will analyze *in situ* the charge state and isotopic composition of ions in the solar wind, and the charge and isotopic composition of energetic particles



**esa**

European Space Agency  
Agence spatiale européenne

**NASA**

# National Solar Observatory Kitt Peak



The National Solar Observatory (NSO) is part of the National Optical Astronomy Observatories (NOAO) which was formed in 1984. NSO operates two major observatory sites. On **Sacramento Peak** in southern New Mexico (picture shown above left), major telescopes include the Vacuum Tower Telescope, the John W. Evans Solar Facility, and the Hilltop Dome. Sacramento Peak has been a center of solar research since 1950; the observatory is a cooperative undertaking of NSO and the Air Force Phillips Laboratory. On Kitt Peak, outside of Tucson, Arizona, NSO

# Mauna Loa Solar Observatory

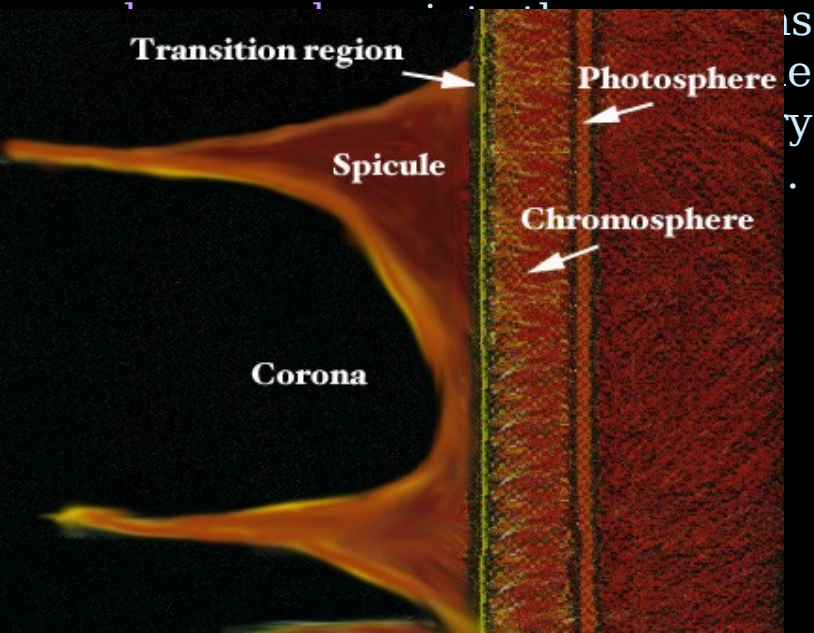


The Mauna Loa Solar Observatory (MLSO) operates daily, weather permitting. Data collected by instruments at the site are:

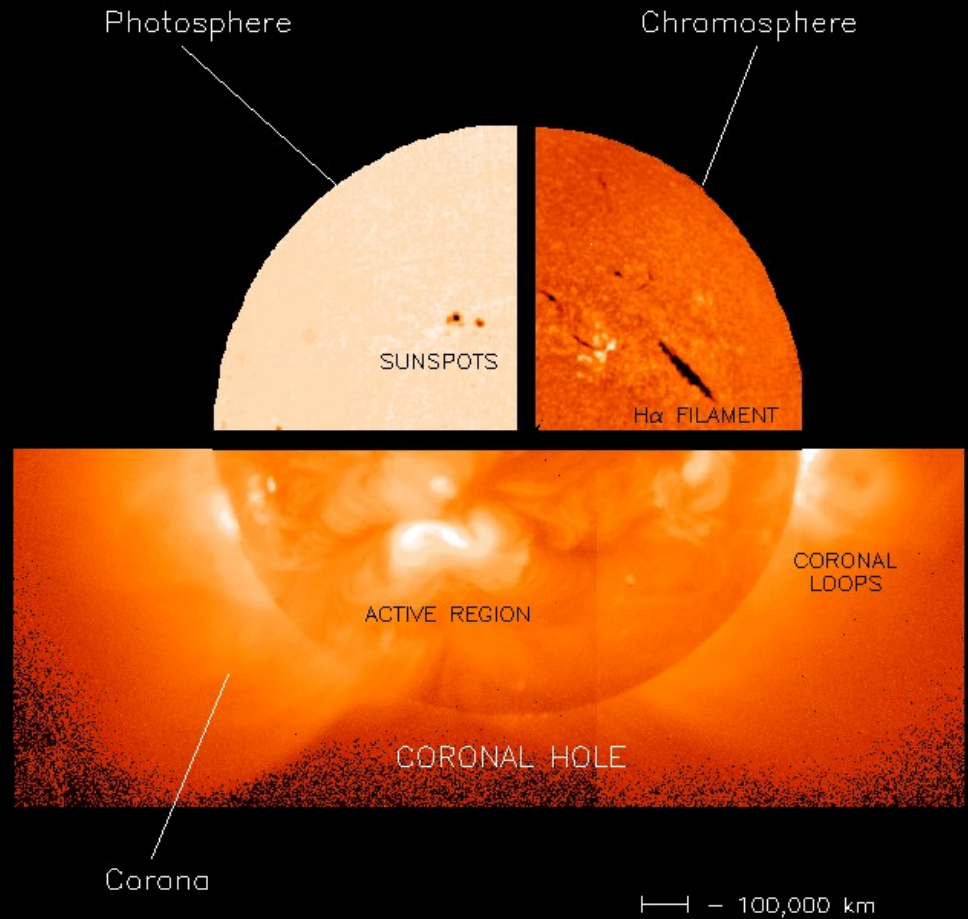
- **H $\alpha$  disk and limb** images, collected with the digital prominence monitor.
- **Coronal images in white light polarization brightness**, collected with the Mark 3 K-coronameter.
- **Solar oscillation data** collected with the Low Degree instrument.
- **Helium I** images, collected with the Chromospheric Helium I Imaging Photometer

# Solar Atmospher

The **photosphere**, shown as an orange vertical line, is the region where sunspots are formed. The less dense and turbulent **chromosphere** is a rapidly-changing filamentary structure that is seen during eclipses as a bright red ring around the Sun. The intensely active transition region, illustrated by the vertical yellow line, was first observed in detail by Skylab in the late 1970s. Spicules extend the



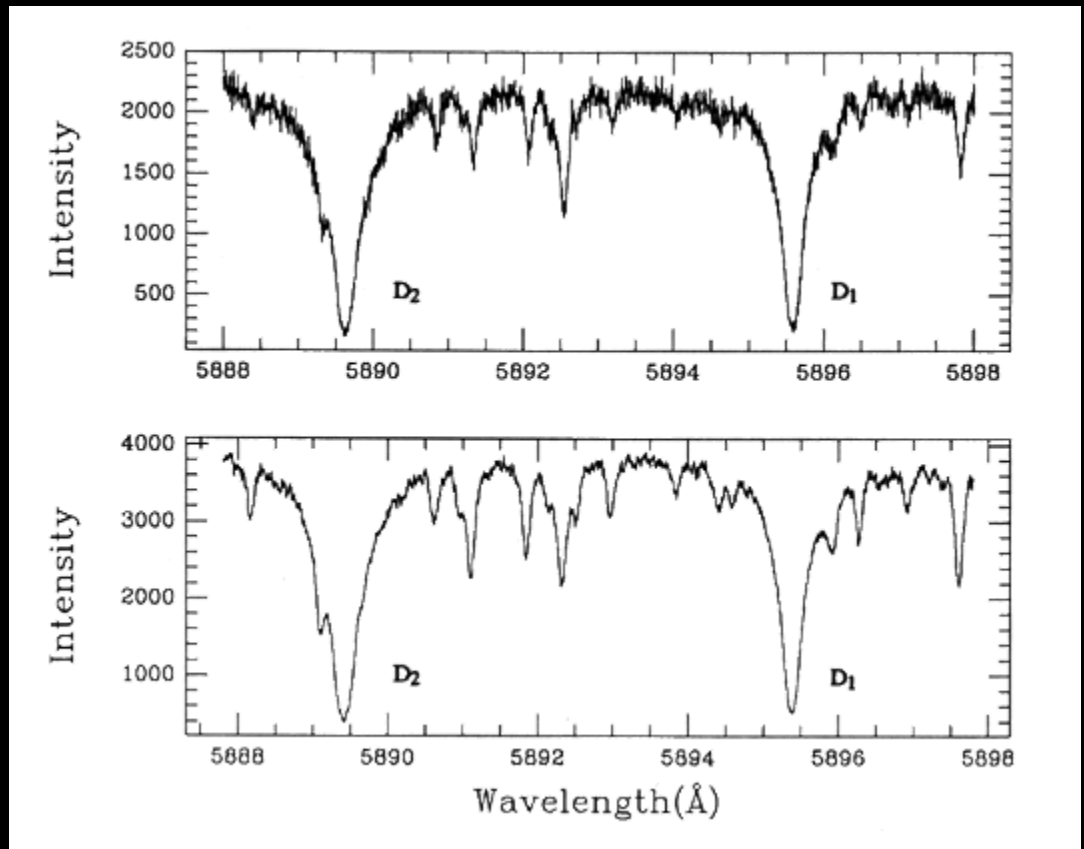
## THE SOLAR ATMOSPHERE



# Photosphere

Figure shows two scans of the solar spectrum in the region of the sodium Fraunhofer D lines at 5890 Å and 5896 Å.

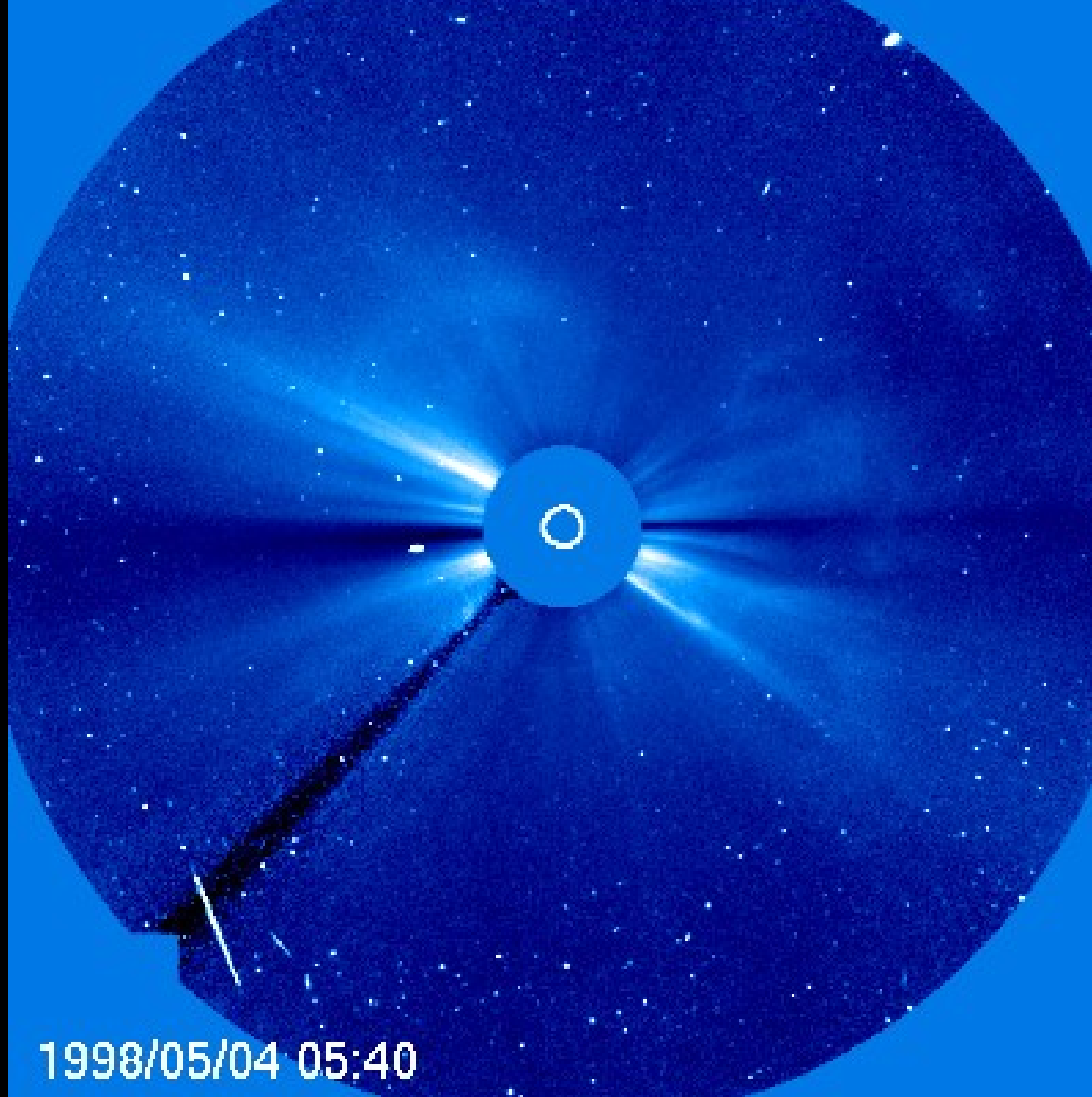
Several of the weaker features are due to water vapor in the earth's atmosphere, and show different strengths in these two scans because of the difference in



**The Solar photosphere** is the region that is optically thick to visual continuum light; thus it is the lowest portion of the Solar atmosphere that can be observed with optical telescopes. Solar spectra show continua and emission and absorption lines. In the visible region, however, the sun shows an absorption line spectrum superimposed on a quasi-blackbody continuum formed in the solar interior. The absorption lines are formed as the continuum radiation passes through the cooler outer layers of the sun and through the earth's atmosphere. Each line corresponds to one (or more, in the case of several close, blended features) absorption line. Physical

# Corona

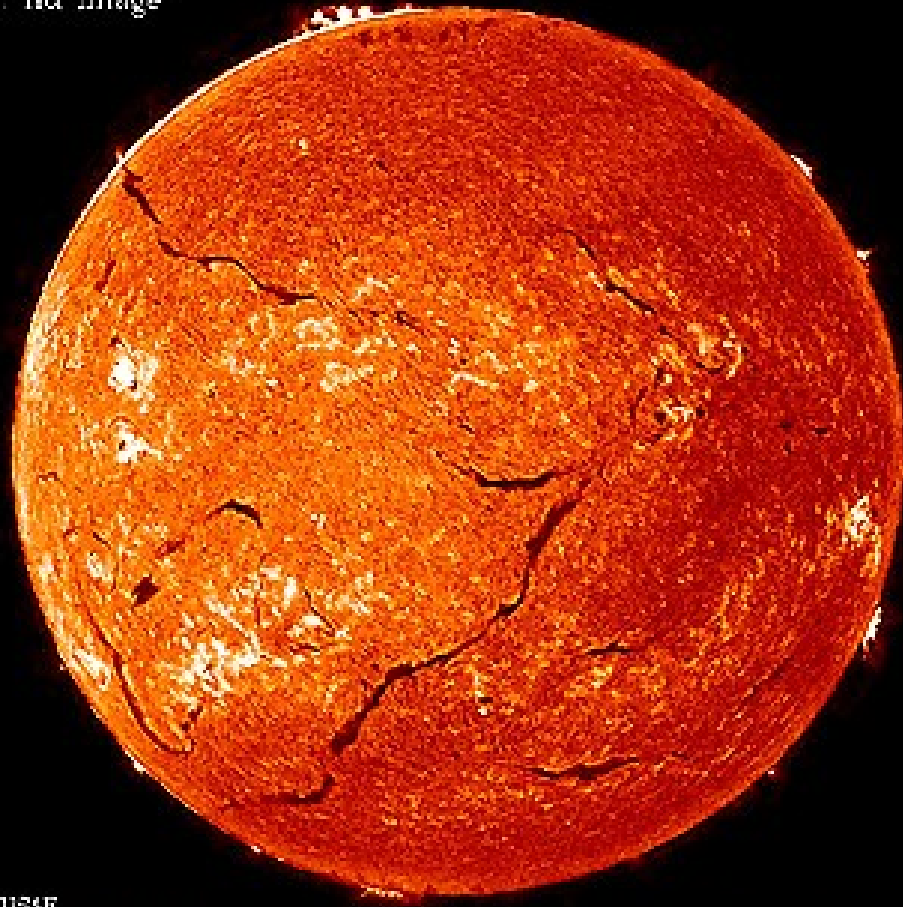
**The Solar corona is the outermost layer of the solar atmosphere, characterized by low densities ( $<10^9 \text{ cm}^{-3}$ ) and high temperatures ( $>10^6 \text{ K}$ ) that extends to several solar radii. The shape of the corona is different at solar maximum and solar minimum. The heating of the corona has been a long-**



1998/05/04 05:40

11 August 1980: H $\alpha$  image

# Chromosphere

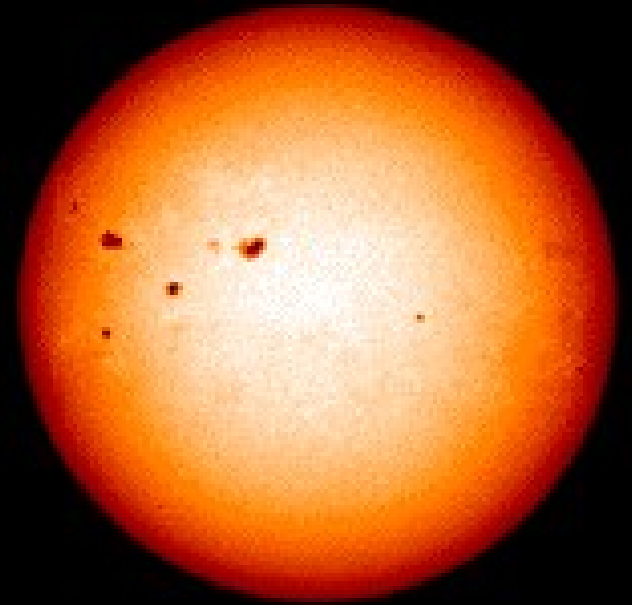
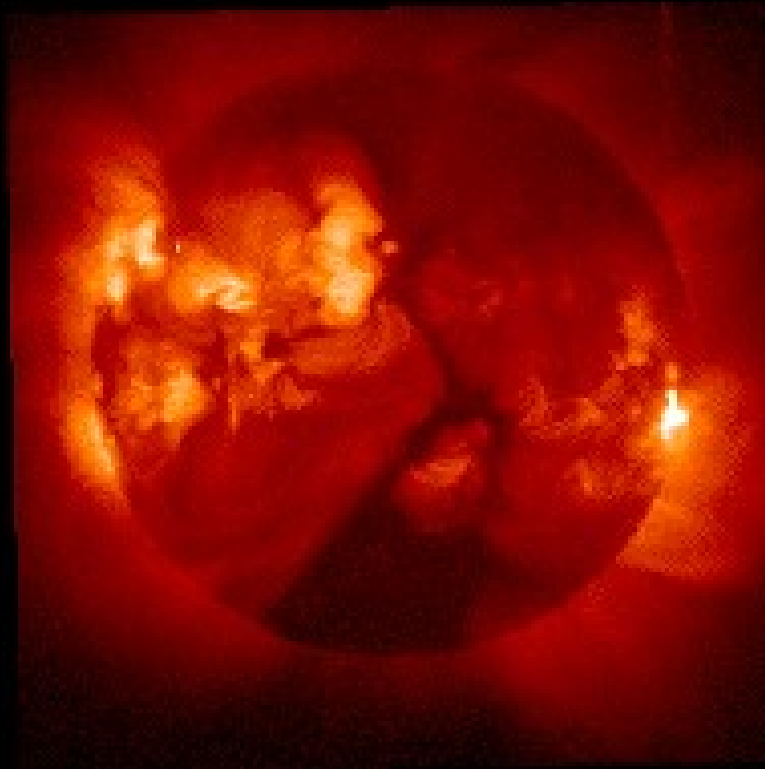


Source: NOAA/SEL/USAF

H10 A-005

**The Solar chromosphere** is the ~2000 km thick layer of the **solar atmosphere** above the (temperature-minimum) transition region and below the **corona**. Being transparent in the continuum, it is seen during eclipses as a bright red ring around the Sun. Energy is transported by radiative diffusion through the chromosphere, which reveals itself most strongly in the light of H $\alpha$  and CaII K. Views of the chromosphere show convective cell patterns similar to those in the photosphere, but much

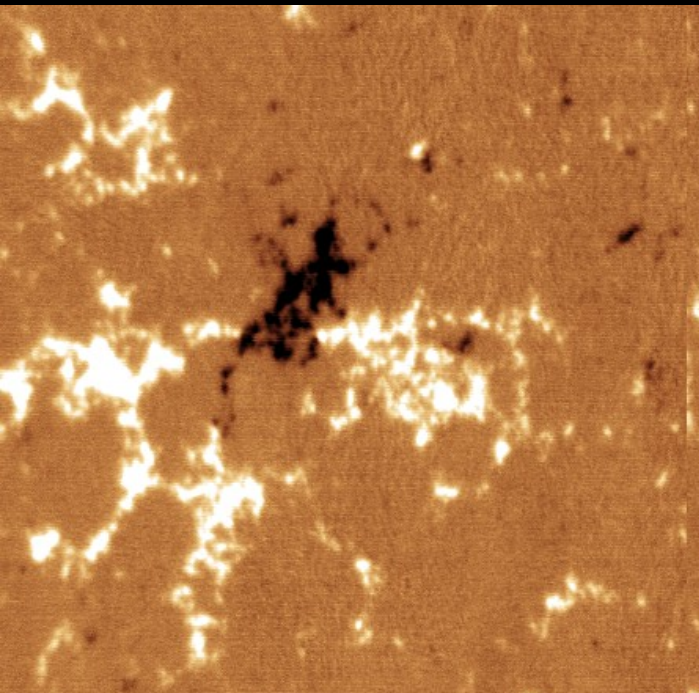
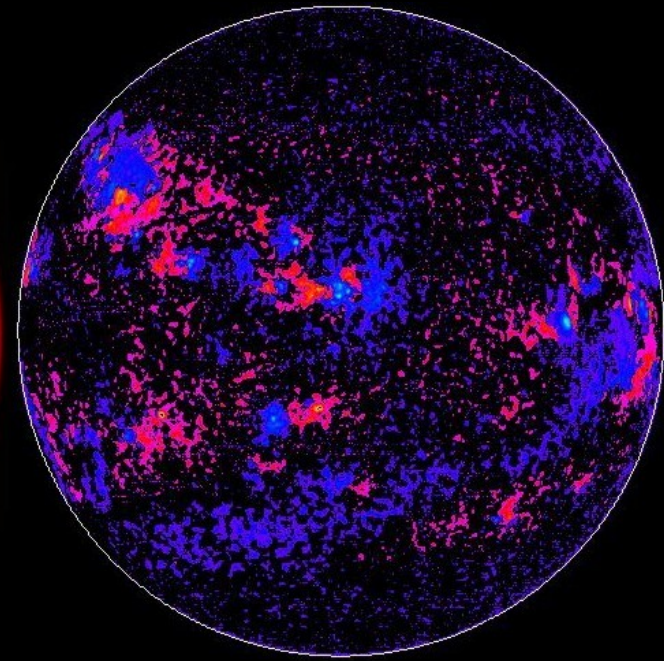
# Coronal Holes and Active Regions



This image at left from [Yohkoh](#) shows the Solar [corona](#). The bright features represents magnetically-trapped plasma. In contrast, the dark regions, known as **coronal holes**, are where the Sun's magnetic field extends out into space, allowing the hot gas to escape. These regions contain material which is cooler than the surrounding  $\sim 10^6$  K plasma seen in soft X-rays, and often appear near the Sun's poles as seen above.

Active regions are formed when magnetic field lines of the Sun emerge from the [photosphere](#) and open into the [corona](#). Hot gas is visible near the magnetic field, making bright loops. Active regions may last for

# Solar Magnetograms



Magnetograms are maps of the line-of-sight component of magnetic flux at the photosphere, the sun's visible surface. The fields are measured by detecting the Zeeman shift between right-hand and left-hand circularly polarized light in a suitable magnetically sensitive absorption line. Only the line-of-sight component can be measured this way. Upper left: 10 Å Ca K line; upper right is corresponding magnetogram. Light and dark areas in image at left show where the field is large and directed out of and into the Sun, respectively.